

Observations of limb rust-infected Jeffrey pines on a homesite at Aspendell, Inyo National Forest, Inyo County, CA (C05-3)

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On August 3rd, 2005, I visited Aspendell with John Pronos, forest pathologist, Beverly Bulaon, forest entomologist, and Scott Kusumoto and Tom Higley of the Mammoth and Mono Lake Ranger Districts. Aspendell is a residential development in the Bishop Creek Drainage some 17 miles west of Bishop, CA on Highway 168, just northeast of Sabrina Lake. The homesite visited is situated in T. 8S, R. 31E, section 20, approx. coordinates 37° 14.196' N, 118° 35.956' W (see circled area in Fig. 1, below).

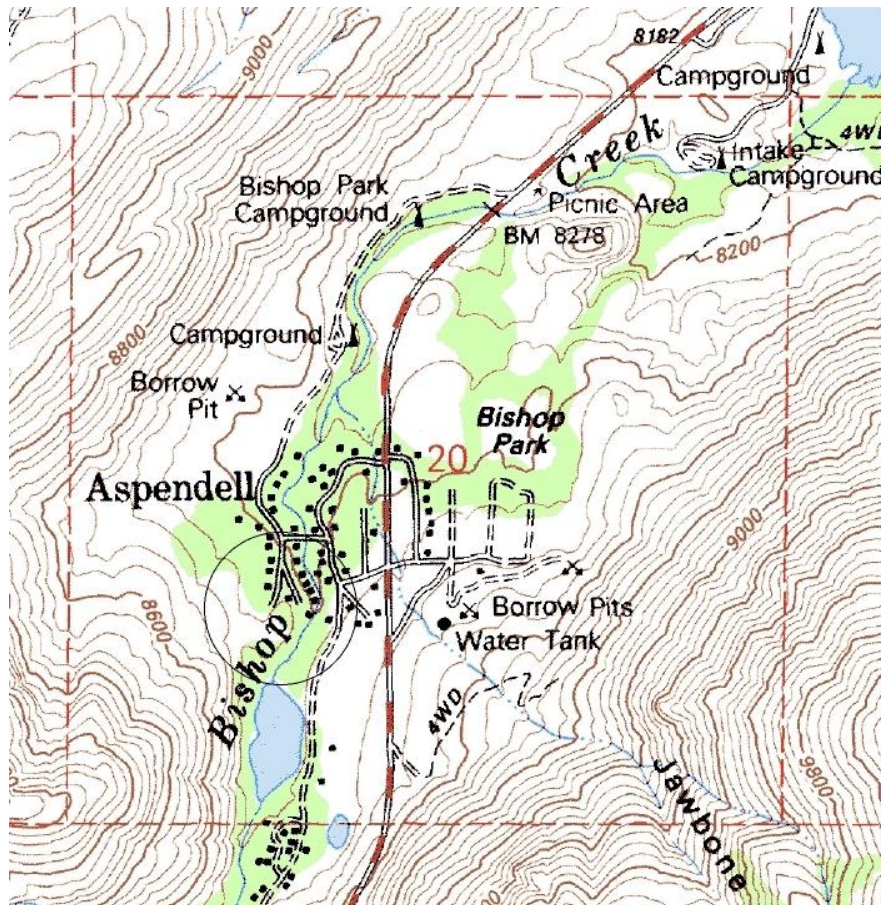


Fig. 1. Site map of the Aspendell residential development.

In early July, Tom Higley notified John Pronos of several Jeffrey pines at Aspendell that were browning from the lower crown upward, and wondered what might be the problem. Although the photos accompanying Tom's request were not definitive, the general pattern of damage to the pines was reminiscent of limb rust (caused by several fungi in the closely-related genera *Cronartium* and *Peridermium*). Nevertheless, the symptoms were not entirely unequivocal, and no signs of rust infection were evident from the photos.

Close observation revealed that several of the symptomatic pines had been damaged by burn piles placed too close to them, thereby scorching the crowns from the bottom upward when the piles were burned in the winter. One tree between two residences, however, seemed to merit closer attention (Fig. 2).



Fig. 2. Suspect limb-rusted Jeffrey pine at Aspendell.

Generally, limb rust spreads slowly from the lower crown upwards or from mid-crown in both directions, limbs die over many seasons from intensifying tissue colonization and from fungal sporulation (which often leads to weakening of the branches from cumulative

wounding), and infected trees can survive for decades with little obvious decline of terminal growth from year to year, despite substantial loss of branches. In this case, the apparently simultaneous and recent branch mortality was unusual. Closer observation revealed the cause (Fig. 3).



Fig. 3. Jeffrey pine limbs chewed at the base by rodents, leading to branch death.

Rodents are often attracted to the sweet and fragrant fungal exudates that are produced on rust-infected limbs in late spring and early summer. Technically, these exudates are masses of spores called **spermatia** or **pycnia**. These are not infecting spores, but instead play a role in the life cycle of the rust fungi by fusing two haploid spore states to produce binucleate fungal **hyphae** (the vegetative “body” of a fungus, composed of many individual filaments that, in mass, are called **mycelium**). The hyphae ramify throughout the host tissue, absorbing nutrients from the host, and eventually form **aecia** and **aeciospores** on the surfaces of infected host tissue. Aeciospores are the familiar rust-colored spores that are often seen on infected pines in the spring and early summer, and that infect alternate hosts (in the case of white pine blister rust, these aeciospores infect gooseberries and currants, *Ribes* spp., while in the case of limb rust they often — but not always, more on that later — infect *Castilleja* spp.).

Once rodents have been attracted to the external spermatia, they often continue to chew through the bark, since developing spermatia may not yet have emerged through the bark surface. Nevertheless, the spermatia within the inner bark are already sweet and fragrant and thus entice hungry rodents to remove all the bark and phloem until the branch is girdled and dies.

In mid-summer, the spermatia, aecia (with enclosing, foliar-like structures called **peridia**), and aeciospores (which are formed within and emerge from the aecia) are no longer obvious on the surface of infected branch tissue, even though one might observe traces of aeciospores upon closer observation (Fig. 4).



Fig. 4. Scattered traces of aeciospores (in minute, orange masses of spores) clinging to bark fissures on a Jeffrey pine limb. Pitch is emerging from wounds chewed through the bark by rodents seeking sweet-tasting fungal spores and fungal hyphae.

The actual peridia that enclose aeciospores occasionally leave traces in mid-summer that can still be observed. At Aspendell, we found several small, dead branches (Fig. 5) that still had peridia. At the peak of production, these appear orange because of the aeciospores inside them, but by July they are white because the spores have all been discharged. Other than peridia, however, an infected branch will bear few traces of infection for most of the year; unlike white pine blister rust, limb rust causes little

swelling of infected branches. Thus, most forest workers fail to see the presence of limb rust until many years after it has first infected individual trees or stands, when cumulative branch mortality has made infection fairly obvious to even the casual observer.



Fig. 5. White peridia, from which aeciospores have all been shed, on a limb rust-infected Jeffrey pine branch.

Until recently, the limb rust infecting Jeffrey pine in this geographic area was thought to be the same organism that causes stalactiform or canker rust on lodgepole pine (*Cronartium coleosporioides*), since both fungi alternate from pine to paintbrush (*Castilleja* spp.) to pine. Recent DNA analyses reveal that this is not the case (Fig. 6). Molecular genetics shows that *C. coleosporioides* and Jeffrey pine limb rust are not closely related (Fig. 6). In fact Jeffrey pine limb rust is far more closely related to a rust called Inyo limb rust, which infects Jeffrey pine at Round Mountain near Tom's Place. The only readily-observable difference between these two rust fungi is that the former alternates to *Castilleja* species to complete its life cycle, while the latter infects directly from pine to pine without passing through an Angiosperm host.

From evidence of Jeffrey pine limb rust at Lake Sabrina and elsewhere west of Highway 395 in similar wet habitats, I am assuming that the fungus at Aspendell is in fact the host-alternating Jeffrey pine limb rust.

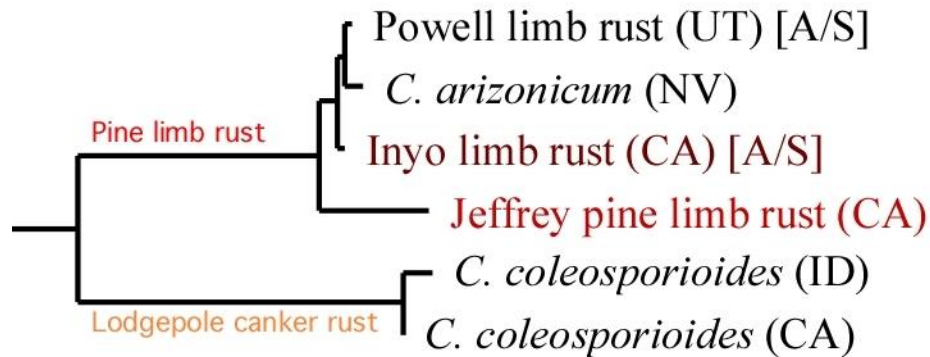


Fig. 6. Phylogeny of the canker and limb rusts. Although all the rust fungi illustrated here are closely related (indicated by the common branching pattern that distinguishes them from other *Cronartium* and *Peridermium* rusts, including white pine blister rust or western gall rust, which are not shown), lodgepole pine canker rust (*Cronartium coleosporioides*) and Jeffrey pine limb rust are separated by a long branch and thus are NOT the same species. Lengths of branches in this tree are proportional to how closely any two fungi are related; the shorter the branch, the more closely related. (Note: A/S indicates that a species is **autoecious** and **short-cycled**; in other words, it does not alternate between pine and *Castilleja* spp., but infects directly from pine to pine.)

Note that, except for *Cronartium arizonicum* and *C. coleosporioides*, none of the other three limb rusts is designated by a Latin binomial. This is because the combined molecular and morphological evidence have not yet been described in the scientific literature, and until then, taxonomic uncertainty continues to exist.

Management of limb rust is difficult, since symptoms usually don't emerge until years after initial infection, and by then the fungus will be well-established in the local vicinity. Eradication of the alternate host, *Castilleja* or paintbrush, would be difficult if not impossible, and even then the costs of eradication would not be commensurate with the benefits to the pines. Limb rust is endemic to this area, and generally does not present a hazard to home owners. Severely limb-rusted trees will continue to survive for decades past when they appear misshapen to humans; the greatest risk they pose is as fire hazards, since the mass of dead limbs may contribute to fire intensity.

In the case described here, rodents have been the early-warning monitors of the presence of infection, and have killed the rust in the branches they have girdled (note that rust fungi are called **obligate parasites**, which means that they only survive as long as their hosts survive). However, given that limb rusts spread through stems and outward into branches, where they **sporulate** (i.e., produce spores), without causing any observable damage to the stems other than the loss of limbs, removal of infected limbs will not stop the spread of infection.

Therefore, a decision on management of limb rust-infected trees in a residential development should be based more on esthetic and physical safety concerns than on forest health issues. Removing the dead branches on the tree in Fig. 2 will not stop the

spread of rust infection, but it is unlikely that rodents will continue to attack the infected branches as they did this spring, and thus this treatment may be satisfactory for many years to come. As noted earlier, limb rust infection kills trees slowly over many decades, and until the consequences of infection become objectionably unsightly, or hazardous to people and structures, there is little risk from keeping the tree pruned and as healthy as possible.